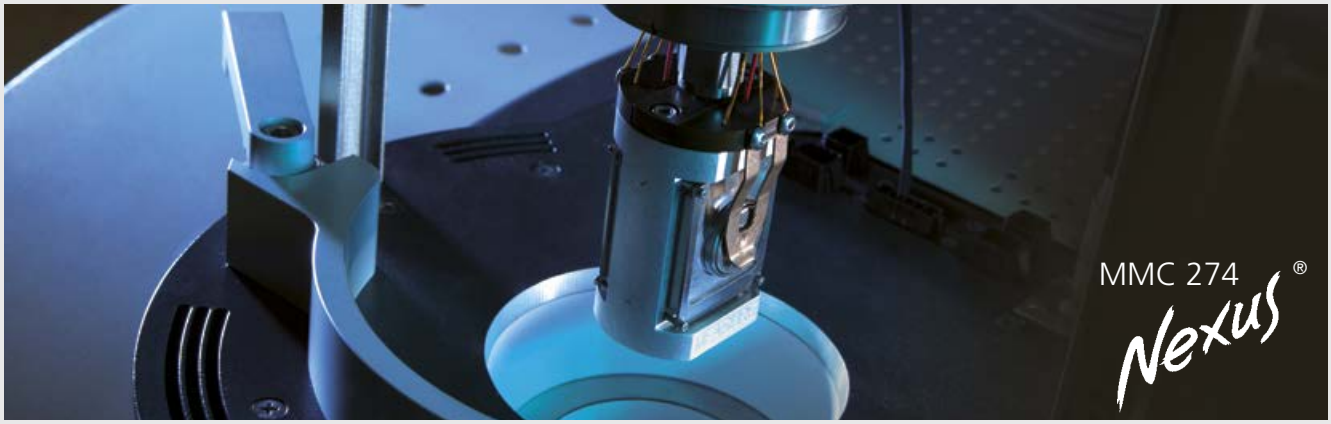
NETZSCH

Analyzing & Testing

Multiple Mode Calorimetry
High Temperature Coin Cell Module

The Only DSC for Research and Quality Control of Coin Cell Batteries



Leading Thermal Analysis

Heat Signature as a Key Component for Battery Development and Testing

Coin cell and typical applications

Many parameters will influence the performance of rechargeable coin cell including temperature and cycling conditions. It is very important for coin cell manufacturer to know the heat generation during charging/ discharging cycles in order to understand the cell energy efficiency and improve cell performance and lifetime. It is also imperative to be able to examine the safety of the whole coin cell when it is subjected to high temperature or cycling abuse.

Measuring the heat signature of coin cells during cycling provides insight as to the underlying processes and provides a quantitative way to compare changes in chemistry beyond current and voltage measurements. Within a coin cell there are many chemical and physical changes which can occur as a function of time, temperature, and of course the cycling load. Some of these are reversible, some occur during the initial few cycles, and others take place over a period of weeks, months, and even years. The amount of heat released or absorbed during all these physico-chemical changes and the rate of the energy change within the coin cell, provides additional pieces of the puzzle and can accelerate the development process. Parasitic reactions and entropic boundary conditions can also be explored with calorimetry improving lifetime and efficiencies.

Heating coin cells and carefully monitoring the decomposition provides information not just on safety but in understanding how formations occur within the cell. For instance, one can clearly see the decomposition of the solid-electrolyte interphase (SEI) as one of the first heat signatures of cell decomposition. By accurately measuring the temperature, energy and rate of energy release the strength of the SEI formation can be evaluated; the larger the decomposition the more energy stored in the SEI layer.

Testing coin cells, complete, half-cells, or single materials in a calorimeter is a proven way to make inherently safer cells and improve development. Obtaining clear onset temperatures of major exothermic decomposition events within the cell, measuring kinetics of these decompositions at higher temperatures is crucial in understanding the behavior of different cell chemistries exposed to internal shorts or hot spots. Designing more robust chemistries is one important route to preventing or mitigating the risk and hazards associated with field failures. Small investments during development can have large financial benefits during product life.

High Temperature Coin Cell Calorimetry – A Powerful, Easy-to-use Solution

A New Module for MMC 274 *Nexus*®

The HT Coin Cell Module is a new calorimeter module for the MMC 274 *Nexus*® specially dedicated to coin cell battery studies. The instrument can be coupled with a fully featured battery analyzer. Data generated from the MMC test is merged seamlessly with the data generated from the cycler/ analyzer allowing for generation of battery and thermal data to be plotted on the same axis. The user can perform discharge tests to evaluate battery condition, cycle batteries to improve performance and gain insight into overall battery condition in an isothermal or temperature scanning mode.

Outstanding Value

- The only dedicated calorimeter for coin cell measurements up to 300°C
- Uses unique differential measuring principal for improved stability and sensitivity to capture even weak heat signals from coin cells
- Characterize coin cells as a whole to mimic cell performance in real world
- Easy to use and runs both isothermal charging/ discharging method and scanning method for complete characterization of coin cells

MMC 274 *Nexus*® and different modules

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Superior Performance, Quality Engineering

General Technical Specifications of HT Coin Cell Module for MMC 274 *Nexus*®	
Temperature range	RT to 300°C
Temperature resolution	0.001 K
Heating rate	0.01 to 5 K/min
Coin cell size (Diameter/Thickness)	5 to 30 mm/1 to 5 mm
RMS noise	10 µW
Energy measurement accuracy	<3%
Energy measurement reproducibility	1%
Standard crucible capacity	500 µl
DSC measuring range	Up to 370 mW
Modes of operation	Isothermal Constant heating DSC
Number of sample cell/reference cell	1/1
Max current	500 mA
Internal wiring (force)	24 awg (0.15 mm)
Internal wiring (sense)	24 awg (0.15 mm)
Footprint (inch) (cm)	19.75 x 15.75 x 22.25 50 x 40 x 57

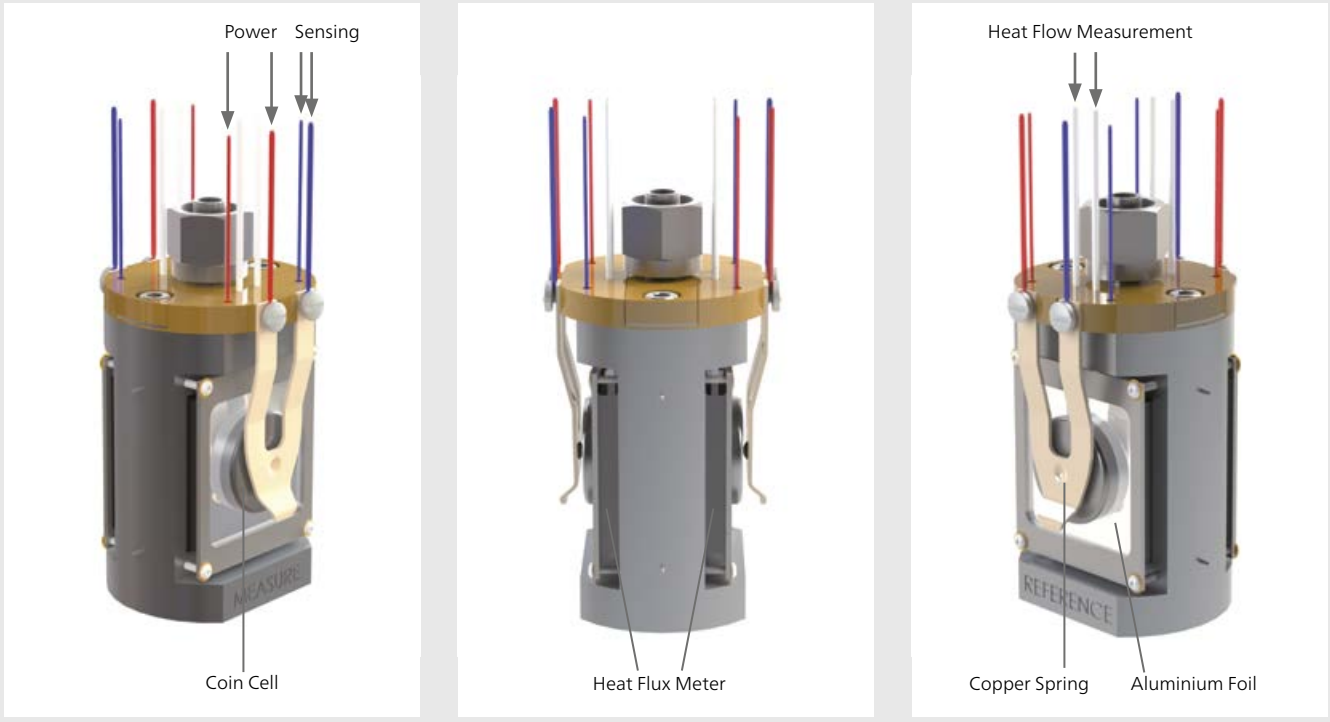
An Innovative, Robust DSC Designed for High Quality Measurement

HT Coin Cell Sensor Assembly

Cross section of HT Coin Cell Module

The key component of this new module is the sensor. It features an innovative differential measurement design based on thermopiles for improved sensitivity and stability of heat flow measurement. The instrument can accept different types of Coin Cell batteries (i.e., LiR2016 and LiR2032). The calorimetric block is equipped with an RTD in order to precisely monitor and control its temperature using the surrounding furnace.

When the coin cell releases or absorbs some heat due to its charging/ discharging or due to internal physical changes, this heat will be detected by the sensor. To avoid the effect of external disturbances, the signal coming from the reference heat-flux meter is subtracted from the signal coming from the sample heat-flux meter – a true differential measurement. A technique much more accurate and sensitive then with a single sensor system.



Schematic of HT coin cell sensor

Connection to External Cycler Made Simple

The Coin Cell HT module for MMC 274 *Nexus*® is designed to be connected to a battery charger/analyzer through a LEMO connector situated in the right side of the instrument's hood. Four wires are used to charge and discharge the coin cell, two for providing the electrical power and two for measuring the exact voltage at the coin cell. Charging/discharging can be handled on both sides of the sensor and data coming from the battery charger can be easily imported into *Proteus*® Analysis for combined analysis.

LEMO connector on the HT coin cell module to a battery cycler – a plug-and-play solution

MMC with HT coin cell module with battery cycler

Complete Characterization of Coin Cell Through Three Flexible Modes of Operation

Isothermal mode

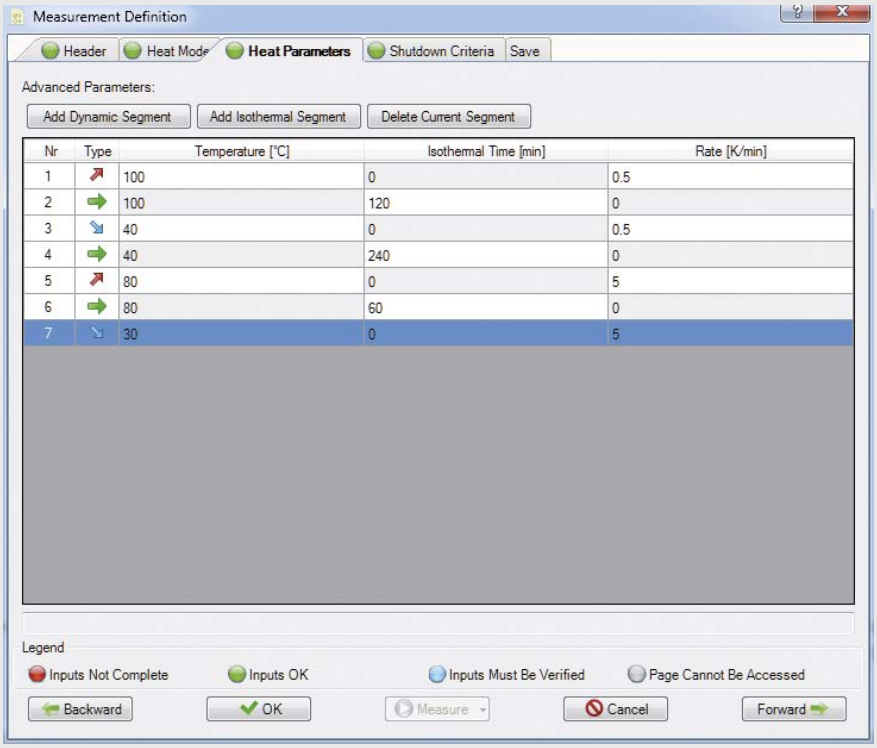
The isothermal mode is usually used to run isothermal experiments (from RT to 300°C) associated with the Coin Cell charging and discharging cycles.

Constant heating mode

The constant heating mode is used to run a linear heating scan (from RT to 300°C). The entire coin cell can be tested to measure successive degradations which occur throughout the temperature range. Different sample holders or crucibles can be used for other material analysis.

DSC mode

This mode allows a user to run DSC experiments. The user can program the method to include multiple constant heating steps and isothermal steps.



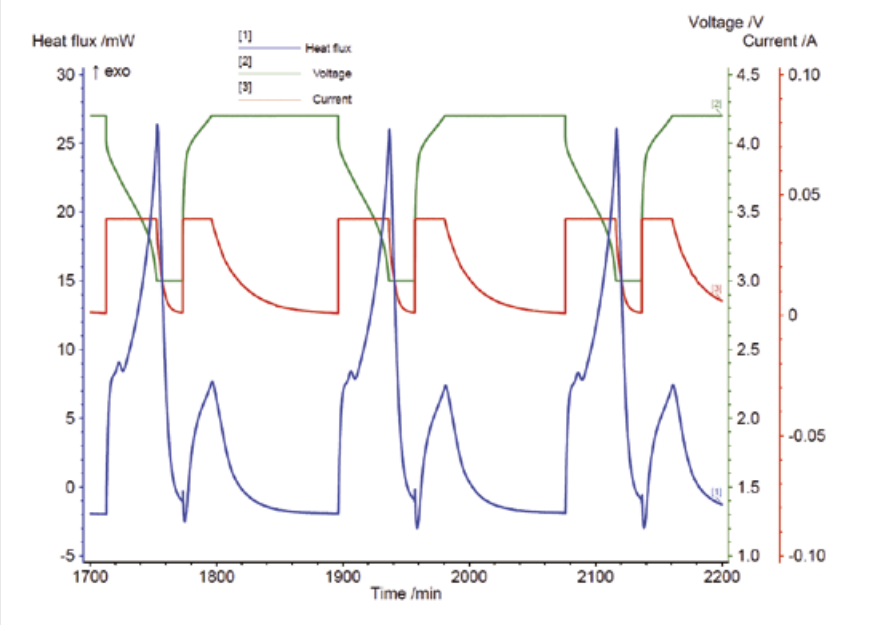
Experiment set up is made easy by the use of NETZSCH standard *Proteus*® measurement software.

Typical Applications

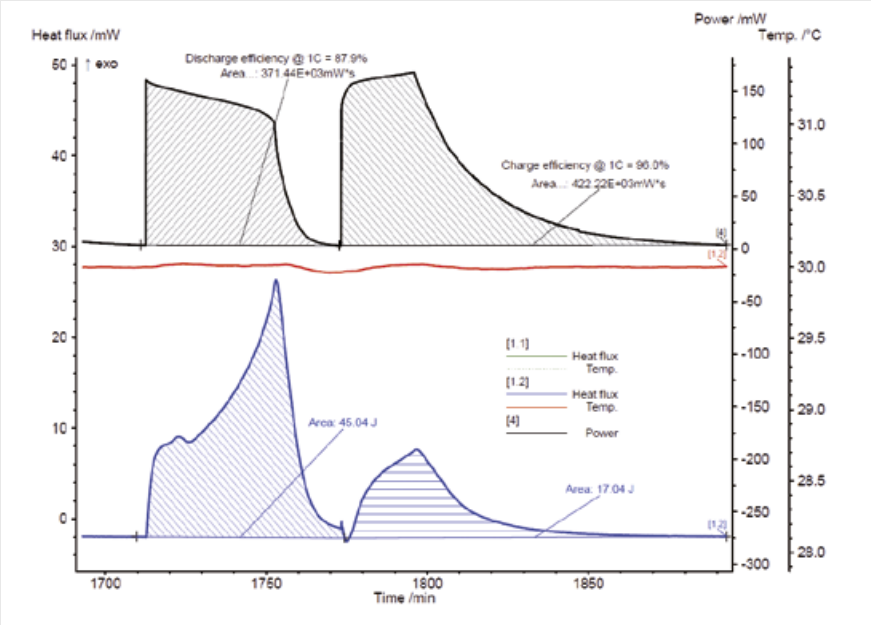
Isothermal charging/discharging experiment

- Type of sample: Coin Cell LiR2032
- Isothermal mode with temperature set at 40°C
- Charging/Discharging cycle Constant current Constant voltage (CC-CV) – 40 mA from 4.2 V to 3.0 V

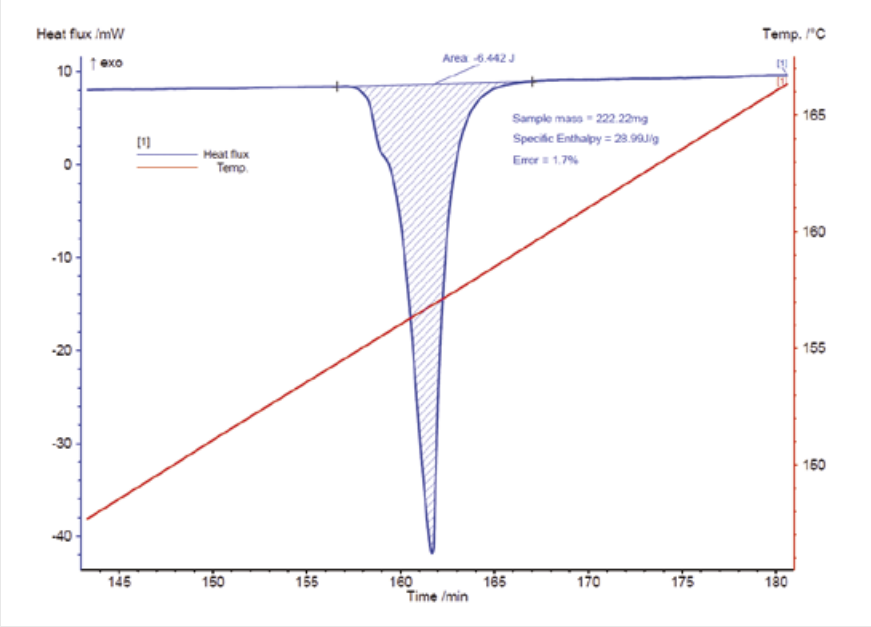
The data shows that charging is characterized by a short endotherm followed by a small exothermic reaction while discharging is characterized by a long exothermic reaction. Cycles are reliably repeatable.



Isothermal charging/discharging of LiR2032 coin cell



The same data was used to calculate the cell efficiency during charging and discharging.

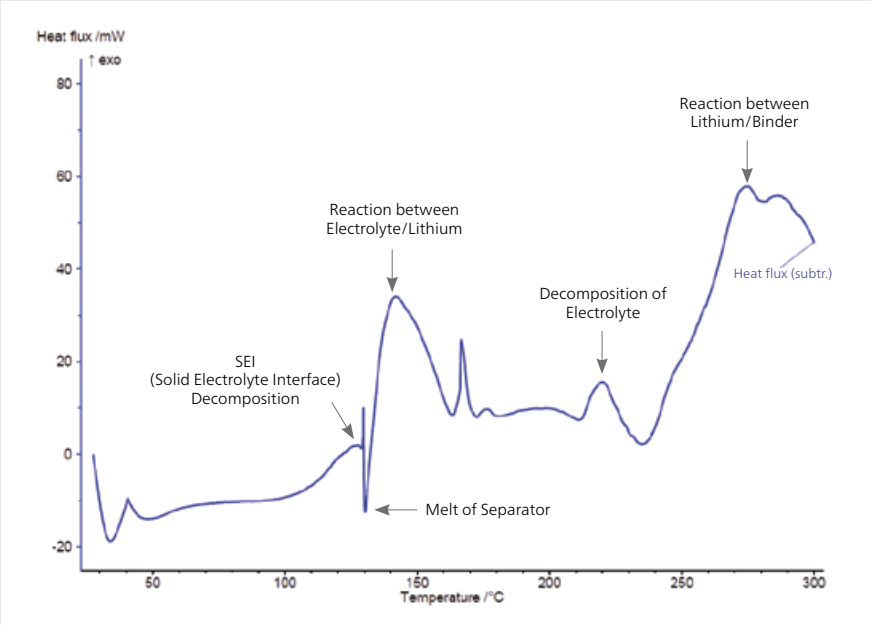


HT Coin Cell Module can be used as a standard DSC, but with very large crucible.

Scanning DSC experiment

The data shows indium melting peak at 0.5°C/min. Good temperature and enthalpy measurements were achieved using a very large Indium sample compared to standard DSC experiment

Coin cell case used as a large DSC crucible (with other typical DSC crucibles)



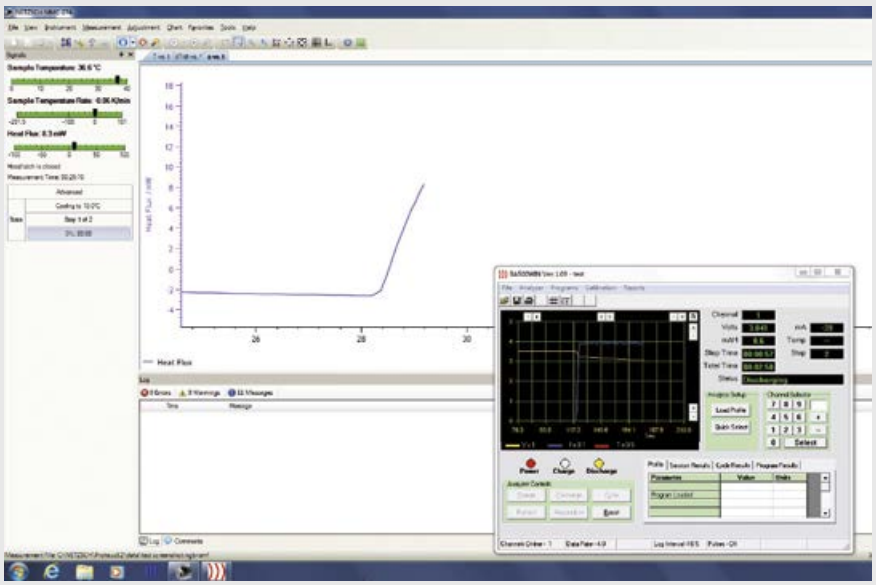
DSC measurement of a fully charged LiR2032 coin cell.

Scanning data of a commercial coin cell LiR2032 from room temperature to 300°C at 1°C/min, showing multiple reactions during coin cell disintegration. It is evident that the exothermic SEI decomposition is followed by the melting of the separator at approximately 130°C (sharp endothermic event). This endotherm occurs nearly simultaneously with the bulk decomposition and reaction of the electrolyte, anode and cathode.

Proven Software Platform Tailored to Battery Applications

NETZSCH *Proteus*® Measurement Software – Proven Technology Leader

- Software automatically customizes itself to the instrument and application
- Intuitive Windows set-up of testing methods with input checks to reduce typos
- Methods can be saved and recalled for later use
- On-line help, comprehensive and easy to understand, available throughout the software
- Data is automatically saved to hard-drive throughout the run
- Intelligent Firmware monitors the status and health of key operating sensors and active components
- Safety integrated with hardware and firmware controls
- Seamless integration of data files to *Proteus*®
- Analysis, NETZSCH Advanced Software Tools or 3rd party software



The NETZSCH Thermal Analysis software *Proteus*® makes the test and data analysis easy.
Inset is the cycler software

Maccor cycler method window

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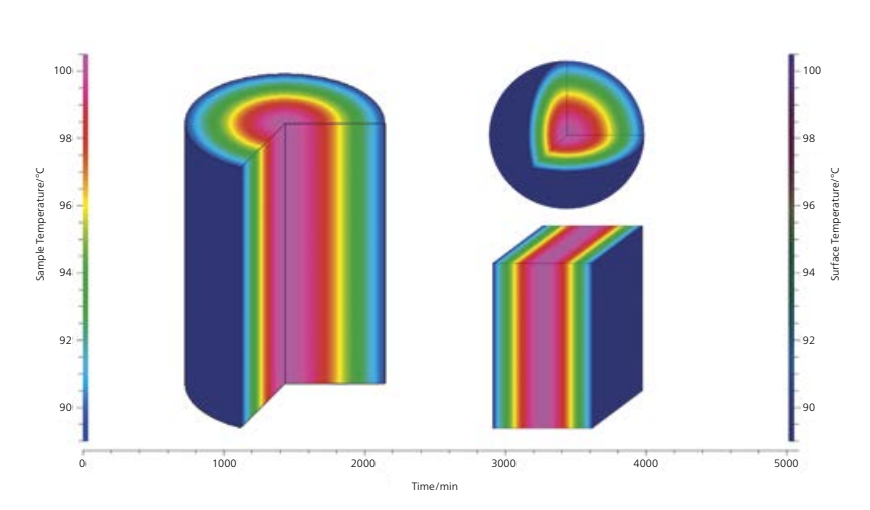
Thermal Simulation

- Simulation of the temperature distribution in battery of different geometries
- Knowledge of consequences for better thermal management



Thermokinetics

- Comprehensive kinetic analysis of multiple reaction steps
- Prediction of temperature and pressure changes for user-defined measurement and storage conditions

Expertise in Service

Our Expertise – Service

All over the world, the name NETZSCH stands for comprehensive support and expert, reliable service, before and after sale. Our qualified personnel from the technical service and application departments are always available for consultation.

In special training programs tailored for you and your employees, you will learn to tap the full potential of your instrument.

To maintain and protect your investment, you will be accompanied by our experienced service team over the entire life span of your instrument.

Summary of Our Services

- Installation and commissioning
- Hotline service
- Preventive maintenance
- Calibration service
- IQ / OQ / PQ
- On-site repairs with emergency service for NETZSCH components
- Moving / exchange service
- Technical information service
- Spare parts assistance

Our Expertise – Applications Laboratories

The NETZSCH Thermal Analysis applications laboratories are a proficient partner for nearly any Thermal Analysis issue. Our involvement in your projects begins with proper sample preparation and continues through meticulous examination and interpretation of the measurement results. Our diverse methods and over 50 different state-of-the-art measuring stations will provide ready-made solutions for all your thermal needs.

Within the realm of thermal analysis and the measurement of thermo-physical properties, we offer you a comprehensive line of the most diverse analysis techniques for materials characterization (solids, powders and liquids).

Measurements can be carried out on samples of the most varied of geometries and configurations. You will receive high-precision measurement results and valuable interpretations from us in the shortest possible time. This will enable you to precisely characterize new materials and components before actual deployment, minimize risks of failure, and gain decisive advantages over your competitors.

For production problems, we can work with you to analyze concerns and develop solutions. The minimal investment in our testing and services will reward you with reduced down time and reject rates, helping you optimize your processes across the board.

NETZSCH

The NETZSCH Group is a mid-sized, family-owned German company engaging in the manufacture of machinery and instrumentation with worldwide production, sales, and service branches.

The three Business Units – Analyzing & Testing, Grinding & Dispersing and Pumps & Systems – provide tailored solutions for highest-level needs. Over 3,000 employees at 163 sales and production centers in 28 countries across the globe guarantee that expert service is never far from our customers.

When it comes to Thermal Analysis, Adiabatic Reaction Calorimetry and the determination of Thermophysical Properties, NETZSCH has it covered. Our 50 years of applications experience, broad state-of-the-art product line and comprehensive service offerings ensure that our solutions will not only meet your every requirement but also exceed your every expectation.

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